Revista de Ingenierías Interfaces, Vol 8 (1) Enero-Junio 2025. ISSN 2619-4473 E-ISSN 2619-4465, pp 1-22.

Microplastics in the Ocean: Scientometric analysis of the scientific literature

Microplásticos en el océano: análisis cienciométrico de la literatura científica

Mariana Rueda-Botero **
Mario Alberto Mejía-Pedrozo ***
Harin Davin Manyoma -Vega ****
Dariana Elieth Torres-Rumbo *****

Recibido: marzo 12 de 2025 - Evaluado: mayo 19 de 2025 - Aceptado: junio 15 de 2025

Para citar este artículo / To cite this Article
M. Rueda-Botero, M.A. Mejía-Pedrozo, H. D. Manyoma -Vega, D. E. Torres-Rumbo, "Microplastics in the Ocean: Scientometric analysis of the scientific literature", Revista de Ingenierías Interfaces, vol. 8, no.1, pp.1-22, 2025.

Abstract

In recent years, scientific and environmental concerns have grown due to microplastic pollution in marine ecosystems. Current studies have shown that microplastics have impacted the trophic network, as they are ingested by marine organisms when mistaken for food, thus affecting their physiology, nutrition, and reproductive success. This article aims to explore the impact of microplastics on the marine food web. Using information collected through scientometric algorithms from queries in the WoS and Scopus databases, a scientometric analysis of the scientific literature produced between 2014 and 2024 was carried out. The countries, journals, and authors who have published on this topic were taken into account. The results indicate the most frequently addressed fields in relation to the effects of microplastics on marine organisms, how these plastics pass from one level to another in the food web, and the ecological implications this entails.

Key words: Microplastics, marine ecosystem, pollution, scientometry.

*Artículo inédito: "Microplastics in the Ocean: Scientometric analysis of the scientific literature".

**Universidad Nacional de Colombia Sede de La Paz, Biology student. maruedab@unal.edu.co, ORCID: https://orcid.org/0009-0007-8376-1938
***Universidad Nacional de Colombia Sede de La Paz, Biology student. mmejiaped@unal.edu.co, ORCID: https://orcid.org/0009-0005-3143-6071
****Universidad Nacional de Colombia Sede de La Paz, Biology student. hmanyoma@unal.edu.co, ORCID: https://orcid.org/0009-0003-4558-5647
*****Universidad Nacional de Colombia Sede de La Paz, Biology student. dartorresru@unal.edu.co, ORCID: https://orcid.org/0009-0009-6467-450X

Resumen

En los últimos años, ha aumentado la preocupación científica y ambiental debido a la polución por microplásticos en los ecosistemas marinos. Los estudios actuales han demostrado que los microplásticos han generado un impacto en la red trófica, dado que son ingeridos por los organismos marinos al ser confundidos por alimento, afectando así su fisiología, nutrición y éxito reproductivo. Este artículo tiene como objetivo explorar el impacto de los microplásticos en la red trófica marina. Empleando la información recopilada mediante algoritmos cienciométricos a partir de consultas en las bases de datos WoS y Scopus, se realizó un análisis cienciométrico de la literatura científica producida entre 2014 y 2024. Se tuvieron en cuenta los países, revistas y autores que han publicado al respecto. Los resultados indican cuáles son los campos más abordados en relación con los efectos de los microplásticos en los organismos marinos, cómo pasan estos plásticos de un nivel a otro en la red trófica, y las implicaciones ecológicas que esto conlleva.

Palabras clave: Microplásticos, ecosistema marino, contaminación, cienciometría.

1. Introduction

In recent years, scientific and environmental concerns have grown due to microplastic pollution in marine ecosystems [1]. These small plastic fragments, less than 5 mm in diameter, have become a global problem due to their persistence in the environment and their ability to accumulate in food chains. It is estimated that between 4.8 and 12.7 million metric tons of plastic enter the ocean each year [2], with approximately 82–358 trillion particles floating in the oceans [3]. Its presence has been documented in up to 50% of the marine species analyzed [4], which highlights the extent of its spread and its serious threat to biodiversity.

The ingestion of microplastics by marine organisms can alter their metabolism, reduce their reproductive capacity, and even cause mortality due to intestinal obstruction or malnutrition [5]. In addition, these contaminants can absorb toxic substances and be transferred through the food web, posing potential risks to species consumed by humans due to their role as vectors of chemical pollutants, such as heavy metals and hydrocarbons, which adhere to their surface and are released into the tissues of organisms that ingest them [6]. However, critical gaps remain in the knowledge of trophic transfer mechanisms and their long-term ecological effects, especially in commercially important species [7].

Given this scenario, a comprehensive analysis is needed to assess trends in research on marine microplastics. This study uses scientometric methods based on data from Web of Science (WoS) and Scopus (2014–2024) to identify patterns of scientific production and international collaborations, analyze predominant methodological approaches, and define priority areas for future research.

The results reveal the regions with the highest academic output, the most prolific journals, and most noticeable authors. This analysis provides a framework to guide mitigation policies and future research efforts in the face of one of the greatest environmental challenges of the Anthropocene [8].

2. Methodology

To carry out this scientometric study on microplastics in marine ecosystems, a methodology based on the analysis of scientific output indexed in the Scopus and WoS databases was used, which are currently considered the most reliable of their kind [9]. These platforms were specifically selected for their extensive coverage of high-impact scientific literature and their ability to provide robust and accurate bibliometric metrics on a large scale [10], as well as his long track record in similar projects such as “Engineering applications of artificial intelligence: A bibliometric analysis of 30 years (1988–2018)” by Shukla et al., [11], who analyzed the bibliographic production on artificial intelligence over a period of 30 years; and Araújo et al., [12], who specifically addressed the literature on the negative effects of microplastics on amphibian health.

In fact, the issue of microplastics and their effect on the ocean ecosystem has been addressed before, in a more general way, in “A global bibliometric analysis of research on microplastics from 2004 to 2020” [13]. Although it has not yet undergone peer review, it is a valuable indicator of the scientific community's growing interest in the subject, even beyond the past decade. Furthermore, this study shows that the disciplines most interested in this field are ecology, chemistry, and environmental sciences, suggesting that it is not a topic exclusive to a single area, but rather that different disciplines must contribute to better understand and tackle this issue.

Other examples of scientometric analyses in the field of natural sciences are the articles by Borowiak and Krzywonos [14], Santos de Moura and Vianna [15], and Valdiviezo Gonzales, [16].

The period covered by this study ranged from 2014 to 2024, with the aim of capturing the most recent developments in research in this field (see Table I). Data collection was carried out using advanced search strategies that combined key terms related to microplastics and marine pollution. Descriptors such as “microplastics,” “ocean,” and “ecosystem” were used. The search was limited to scientific documents published in official journals, excluding other forms of gray literature to ensure the quality of the data analyzed. The search equation used was as follows: (TITLE (microplastics) AND TITLE-ABS-KEY (ocean AND ecosystem)) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (DOCTYPE , "ar")).

Table I. *Search parameters used in WoS and Scopus*

Parameter	WoS	Scopus
Range	2014-2024	
Date	04/11/2025	
Document type	Articles	
Words	(TITLE (microplastics) AND TITLE-ABS-KEY (ocean AND ecosystem)) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (DOCTYPE , "ar"))	
Results	374	513
Total	887	

The analysis of data extracted from WoS and Scopus followed a structured methodology (Figure 1). First, the database was cleaned by removing 409 duplicate records, leaving 478 unique publications, extracted from the initial total of 887 publications, combining the 374 from WoS and 439 from Scopus. This information was then organized into spreadsheets, classifying key variables such as authors, country and year of publication, citation metrics, and journals with their respective quality percentiles [17], [18], [19].

This study enabled the mapping of scientific collaboration dynamics and citation patterns in research on microplastics in marine ecosystems, revealing significant trends in academic output over the last decade, excluding the current year (2014–2024).

The scientometric analysis was complemented by data visualization techniques, such as graphs and tables, which allowed us to identify emerging patterns and trends in marine microplastics research. These were created by processing data using Gephi software (ver. 0.10.1) and two previously developed Python scripts, run on Google Collab.

In addition, it was also observed that the highest production of articles took place in 2024, with a total of 198 publications, more in Scopus (162) than in WoS (121), meaning that there was a difference of 25.31% in favor of Scopus in that year. An interesting fact is that, although 2024 saw the highest number of publications in the last ten years in microplastics research, this was not reflected in the total number of citations, which was the lowest in the last ten years (1,392). This is due to the saturation of initial studies in the early years of microplastics research (2018-2019), that lead to a boom in studies establishing the prevalence of microplastics in different marine environments.

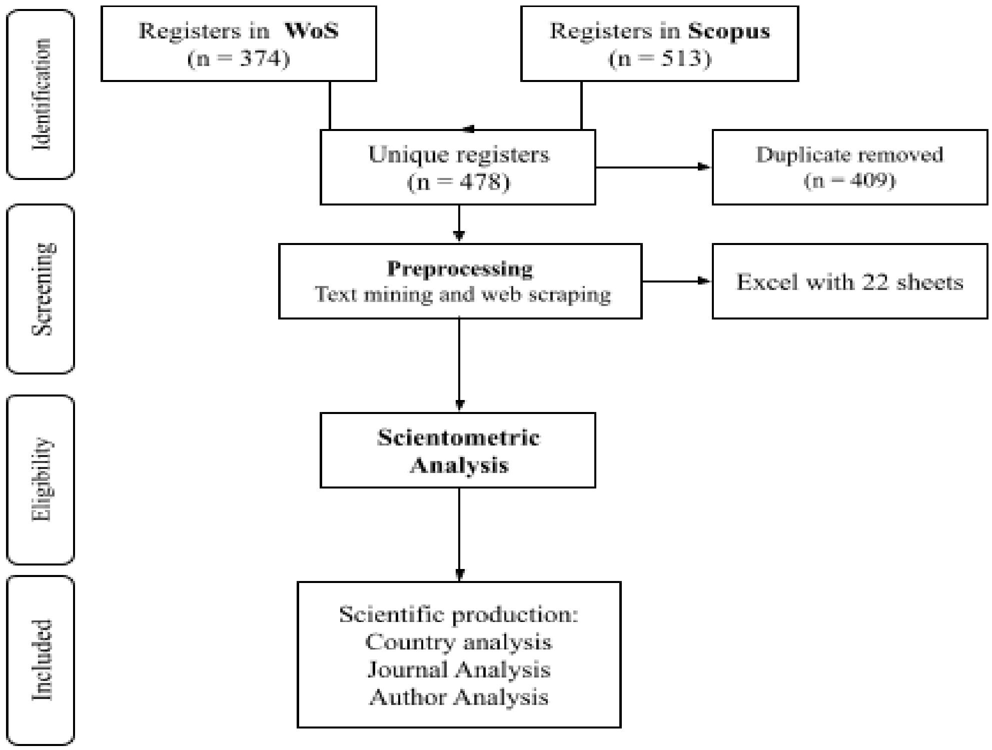

Figure 1: *Detailed process flow diagram.*

These pioneering studies accumulated a large number of citations, as in the case of articles such as “Plastic pollution in the world's oceans” by Eriksen et al. [20], which currently has 3839 citations, because they were the first to document the problem. Once the presence of microplastics was well established, the need to constantly cite those foundational studies diminished.

Scientific Annual Production

The annual analysis of scientific output on a given topic is vital for identifying the most important moments over the period studied.

In this case, Figure 2 shows the annual output on microplastics over the last 10 years (2014-2024), indicating the total number of publications and citations of the articles analyzed. A greater number of publications in Scopus can be observed in all years (green bar); however, Wos production (yellow bar) after 2018 contributes significantly to the total number of publications (red line) with articles not found in Scopus. A significant increase in the production of Scopus articles can also be observed in 2024. Overall, the figure shows a fairly upward trend in total publications (red line), with an average annual growth of 43.1%. For a more detailed analysis, scientific production was divided into three periods, which are explained below: upward trend, stability, and downward trend.

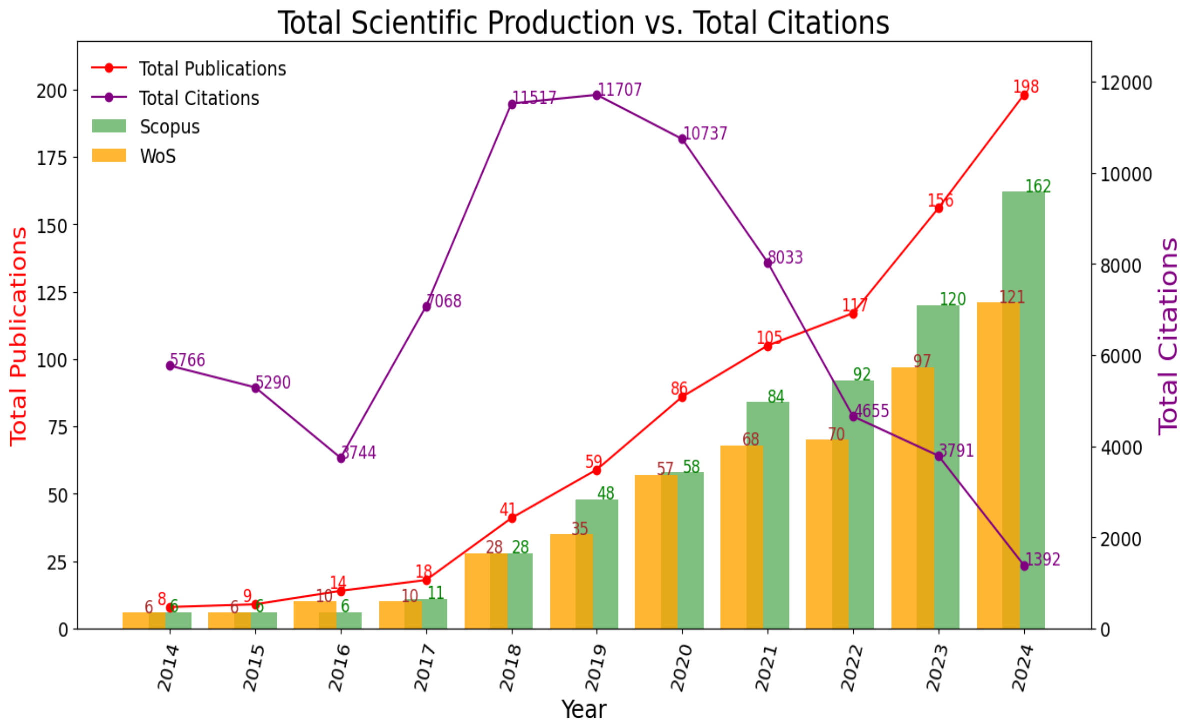

Figure 2. *Annual Scientific Production Chart.*

Period 1. Upward trend (2014–2018)

Scientific output during the period 2014-2018 grew by 56.6%, with an average of 15 publications per year, and was very similar in Scopus and WoS. There are only two years in which there is a difference in scientific output (2016 and 2017), but it should be noted that the difference in output is very small. Figure 2 shows how 2016 was the year when the narrative of microplastics in the sea became a topic of interest to the scientific community, evidenced by a significant increase in the number of publications compared to the previous two years. This upturn coincides with the publication of highly cited articles and influential reviews that highlight the magnitude of the microplastics problem, not only from a biological perspective, but also from the perspective of environmental chemistry and public health.

In 2016, the foundations for the growth of this narrative were consolidated by several research projects, such as: On some physical and dynamic properties of microplastic particles in the marine environment [21], in which it details the importance of understanding the distribution and transport of microplastics in the oceans, as well as their impacts on human health and the environment, another piece of research that was vitally important for laying the foundations in 2016 was "From macroplastic to microplastic: Degradation of high-density polyethylene, polypropylene, and polystyrene in a marsh habitat" [22], in which researchers found that plastics break down into smaller particles called microplastics, which can be dangerous to wildlife and the environment. The study highlights the importance of understanding the degradation process of plastics in natural environments in order to mitigate their negative impact on the ecosystem.

Figure 2 shows that in 2017, the number of citations increased by 88.78% compared to the previous year, despite the fact that the number of publications only increased by 28.57% compared to 2016. This year, the impact of several research projects was particularly high, such as research related to the export of plastic waste from rivers to the sea [23], that have over 1,000 citations.

One of the most important and influential articles published in 2017 was "Microplastics in freshwater and terrestrial environments: Assessment of current understanding to identify knowledge gaps and future research priorities" [24], It has almost 3,000 citations, and a really interesting topic, in which it serves to identify gaps in knowledge so that research can be focused on each of these gaps, thereby consolidating a solid knowledge base in the area.

Furthermore, although there were a significant number of citations in 2017 (7,068), this figure was abruptly surpassed the following year with a total of 11,517 citations in 2018, representing an increase of 62.95%. The number of publications was also surpassed, with an increase of 127.78% compared to the previous year. At this point, the scientific community had focused its research on topics such as microplastics as an emerging threat to terrestrial ecosystems [25], reflected in highly cited rates in a short period of time. This was also the case with research on the trophic transfer of microplastics and mixed contaminants in the marine food web and implications for human health, reflected in articles like the one by [26], that also has more than 1,000 citations.

Period 2. Stability (2018-2020)

Figure 2 shows that between 2018 and 2020, there was a 109.76% increase in the total number of publications, but this increase was not reflected in the number of citations. In the graph in Figure 2, we can see that in 2018, there were 11,517 citations and in 2020, there were 10,737, representing a decrease of 7.2%. This figure shows a consolidation of citations in that range with a variation of less than 10% between 2018 and 2020. During this period, there were influential topics, such as "Future scenarios for global plastic waste generation and disposal" [27], in which the relationship between plastic waste generation and countries' gross domestic product (GDP) was analyzed.
One of the most influential studies was "Projected growth in plastic waste exceeds efforts to mitigate plastic pollution" [28], with a total of 1,976 citations, which is normal because this article discusses how the problem of plastic pollution is a planetary threat that affects almost

all marine and freshwater ecosystems worldwide. However, it also states that even though mitigation strategies are being adopted, it is estimated that between 19 and 23 million metric tons of plastic waste entered aquatic ecosystems in 2016, and annual emissions are projected to reach up to 53 million metric tons per year by 2030.

An interesting fact to note is that between 2018 and 2020, the variation between research publications in Scopus and WoS was less than 10%, except in 2019, when there were 48 publications in Scopus and 35 in WoS, representing a 27.08% difference between the number of research papers in both databases, with more publications in Scopus.

Periodo 3. Tendencia bajista (2020-2024)

It was also observed that the highest production of articles took place in 2024, with a total of 198 publications, more in Scopus (162) than in WoS (121), which means that there was a difference of 25.31% in favor of Scopus in that year. An important observation is that, despite the fact that 2024 saw the highest number of publications in the last ten years in microplastics research, this was not reflected in the total number of citations, which was the lowest in the last ten years (1,392). This may be due to the saturation of initial studies in the early years of microplastics research (2018-2019), as there was a boom in studies establishing the prevalence of microplastics in different marine environments.

These pioneering studies accumulated a large number of citations, as in the case of articles on "Plastic pollution in the world's oceans” [20], which currently has 3,839 citations, because they were the first to document the problem. Once the presence of microplastics was well established, the need to constantly cite those foundational studies diminished.

While the average number of citations per article may stabilize or even appear to decline slightly compared to the initial peak, research on microplastics in the sea has not declined. Instead, it is evolving toward a more mature, specialized, and methodologically rigorous approach.

Country Analysis

Table II shows that China is the country with the highest scientific output, with 152 publications representing 16.26% of the total, followed by the US with 79 publications and the UK with 58 publications (see Table I). European countries such as Germany, Spain, Italy, and France also have a significant presence, although less than the leading countries.

Table II: *Scientific Production and Impact by Country.*

Country	Production		Citation		Quality			
	Count	%	Count	%	Q1	Q2	Q3	Q4
China	152	16.26	7833	11.36	127	8	7	2
Usa	79	8.45	7009	10.17	60	10	1	0
United Kingdom	58	6.2	7699	11.17	46	1	0	0
India	54	5.78	2640	3.83	41	3	3	4
Germany	53	5.67	6366	9.23	42	1	0	0
Spain	45	4.81	3429	4.97	40	2	1	0
Italy	42	4.49	2123	03.08	37	3	0	2
France	30	3.21	2998	4.35	22	0	1	1
Brazil	28	2.99	889	1.29	23	1	1	2
Korea	25	2.67	1149	1.67	18	1	1	2

It is noteworthy that the United Kingdom stands out with 11.17% of citations despite having fewer publications than China and the United States, suggesting a greater average impact per article. Germany, although it has fewer publications, shows a high percentage of citations (9.23%), reflecting the quality and impact of its work.

Other countries, such as India, have good production but less impact in citations, thus standing out for a more balanced distribution in Q1-Q4. Brazil and Korea have less production and citations, but maintain a presence in the quality categories. Some of the notable articles from these two countries are “Microplastics in the pelagic environment around oceanic islands of the western Tropical Atlantic Ocean” [29], with 158 citations; and “Microplastics in the surface sediments from the Beijiang River littoral zone: Composition, abundance, surface textures and interaction with heavy metals” [30], with 492 citations.

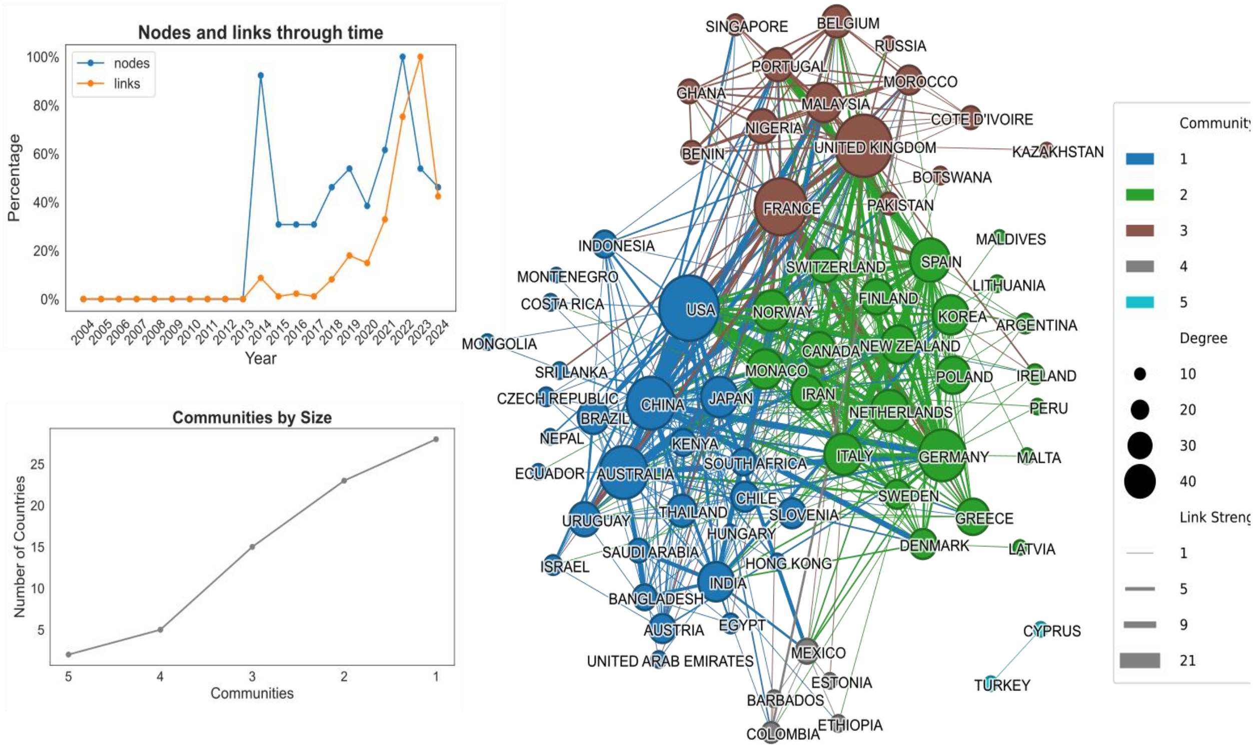

Figure 3: *Global Collaboration Network.*

Figure 3 shows a scientific collaboration network between countries researching the impact of microplastics on marine ecosystems. The graph illustrates the structure and dynamics of the collaborations, highlighting the presence of five communities differentiated by color and size. Among them, communities 1 and 2 emerge as the most dominant, grouping 28 and 22 countries respectively, reflecting intense research activity in these regions.

Among the communities with the most interconnections, there is a high rate of collaboration between China and the US, which are in fact the main producers of microplastics on the planet [31]. As Huang et al. [32]; [33] stated, China was the leading producer of plastics in 2010, and by 2018 it had become the source of one-third of the world's microplastics [34]. These figures reflect China's dual role as the world's largest manufacturer and consumer of plastics, underscoring its decisive impact on international markets and the associated environmental consequences [32].

Journal Analysis

This journal analysis presents information on citations in various databases for scientific journals focused on environmental sciences and pollution (see Table III). The most cited journals are Marine Pollution Bulletin (130 citations) and Science Of The Total Environment (126 citations), which stand out considerably from the rest; there is a significant gap between the top three journals and the rest. This reveals a clear picture of the distribution and scope of publications in the area of study.

Table III: *Scientific Production by Leading Journals.*

Journal	Wos	Scopus	Total
Marine Pollution Bulletin	58	103	130
Science Of The Total Environment	70	106	126
Environmental Pollution	52	60	84
Journal Of Hazardous Materials	20	30	33
Chemosphere	12	23	27
Frontiers In Marine Science	23	21	23
Environmental Science And Pollution Research	9	12	18
Environmental Science And Technology	0	16	16
Scientific Reports	9	10	11
Water Research	8	7	10

Marine Pollution Bulletin ranks as the most prolific journal, with a total of 130 publications, closely followed by Science of the Total Environment (126) and Environmental Pollution (84). Their top articles on the subject are, respectively: “Microplastics in the marine environment” [35] with more than 6,000 citations; “Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities” [24], with 2,898 citations; and “Microplastics in aquatic environments: Implications for Canadian ecosystems” [36], with 485 citations.

These three journals account for most of the publication output, suggesting their relevance and specialization in the topics addressed. In contrast, journals such as Water Research (10) and Scientific Reports (11) show a significantly lower contribution, possibly due to their focus on more specific areas or a lower frequency of publication on the topics analyzed. Their top articles are, respectively: "Preferential accumulation of small (<300 µm) microplastics in the sediments of a coastal plain river network in eastern China" [37], with 199 citations; and "Microplastics profile along the Rhine River" [38], with 809 citations.

When comparing the databases, it becomes evident that Scopus records a higher number of publications than Web of Science (WoS) across nearly all journals. Marine Pollution Bulletin has 103 records in Scopus compared to 58 in WoS, while Science of the Total Environment shows 106 in Scopus and 70 in WoS. This trend may indicate that Scopus offers broader coverage in these subject areas. However, a striking case is Environmental Science and Technology, which has no records in WoS (0) but appears with 16 entries in Scopus—raising questions about potential indexing biases or differing selection criteria between the two databases.

A noteworthy aspect is the discrepancy between the total reported values and the simple sum of WoS and Scopus entries. For instance, in the case of Marine Pollution Bulletin, the combined total from both databases (58 + 103 = 161) exceeds the indicated overall total (130), suggesting that the latter may represent unique publications, with duplicates between databases removed.

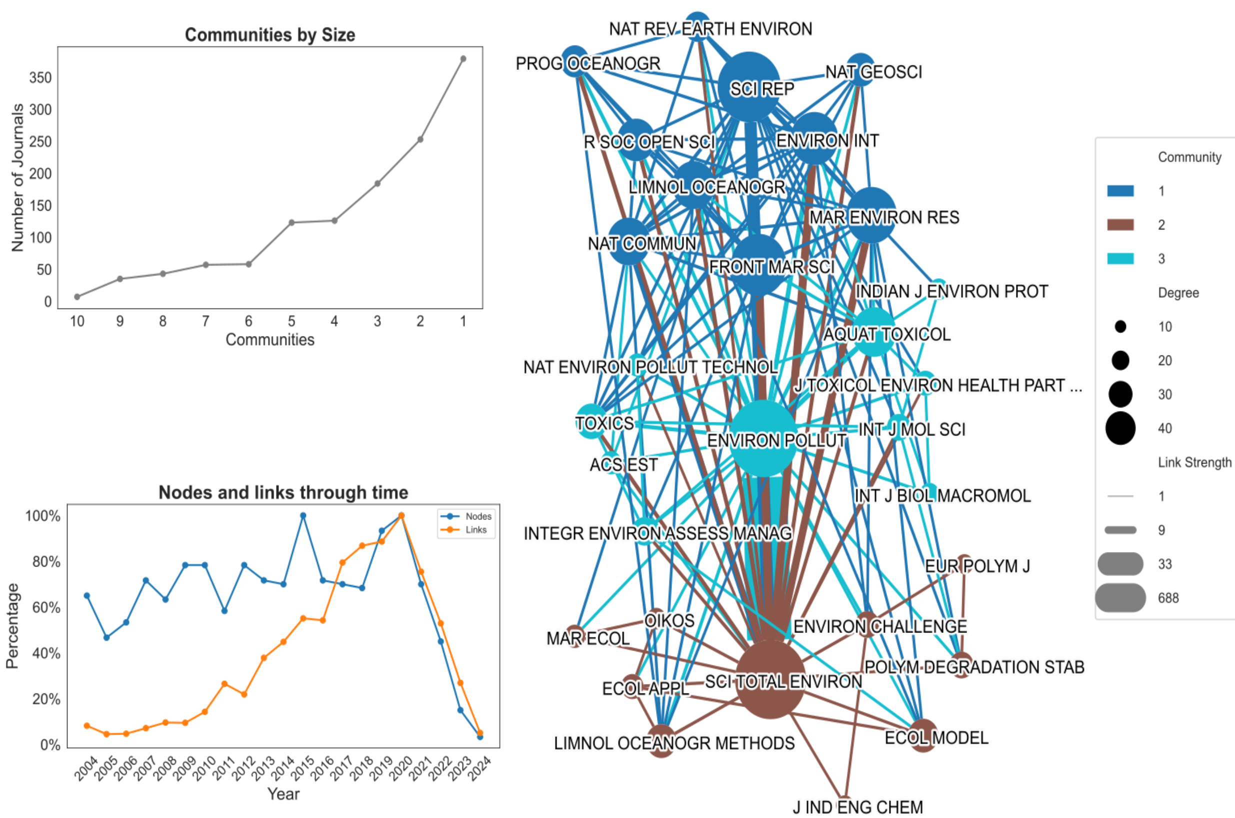

Figure 4: *Scientific Production by Leading Journals.*

In terms of relevance, the journals with the highest output—Marine Pollution Bulletin, Science of the Total Environment, and Environmental Pollution—not only dominate quantitatively but may also reflect a greater impact in the field due to their thematic specialization. On the other hand, journals such as Chemosphere (27 articles) and Frontiers in Marine Science (23 articles) show a moderate presence, while Environmental Science and Pollution Research (18 articles) and Environmental Science and Technology (16 articles) appear with fewer contributions, possibly due to their focus on more specific subfields.

Author Analysis

The author analysis allows us to identify the most active individuals in the field, as well as their patterns of scientific collaboration. It details their networking strategies and enables us to assess the importance of researchers based on their scientific output and the impact of their publications.

Table IV presents the ten authors with the highest academic output on the topic of microplastics in marine environments. The results show that Dr. Wang Yanting has the highest scientific production, with 23 articles, ranking fourth in terms of citation impact (960) and second in h-index (14). Although Professor Wang Jun has fewer publications (19), he holds the highest impact (1,701 citations) and the highest h-index (15). A particularly interesting finding is that Professor Wang Zheng, despite having a lower number of publications (12), ranks third in terms of citation impact (1,172), demonstrating the high relevance of his contributions.

Table IV: *Scientific Production by Leading Authors.*

Author	Papers Total	Total Citations	H-Index	Effective_Size	Constraint	CDI
Wang Y	23	960	14	529.35	0.01	0.04
Li Y	20	922	10	469.94	0.01	0.04
Wang J	19	1701	15	459.03	0.01	0.04
Li J	18	1500	12	414.71	0.01	0.04
Lee Y	12	119	6	50.11	0.06	0.15
Wang Z	12	1172	10	337.06	0.01	0.05
Chen X	10	240	7	192.59	0.02	0.05
Xu X	10	694	8	176.92	0.02	0.05
Zhang Y	10	505	7	529.15	0.01	0.04
Kim J	9	147	5	104.95	0.03	0.14

Regarding the social network analysis (see Figure 5), node size reflects the level of collaboration among authors. In Table 4, most professors (6) exhibit a low constraint value (0.01). This low constraint observed among the majority of authors suggests that their collaborations tend to occur within tightly knit academic circles. While this may limit the diversification of perspectives, it can also foster specialization and depth in specific research areas.

Authors such as Professors Wang Jung and Li Jingxi have focused their research on the geographic distribution of microplastics in marine environments [39]; [40], whereas others, like Professor Xu Xiyuan, have concentrated on marine toxicology [41]; [42], highlighting the importance of investigating the combined effects of microplastics and tetracycline on marine ecotoxicity. This thematic diversity illustrates the field's increasing multidisciplinarity, facilitated in part by the overall low average constraint.

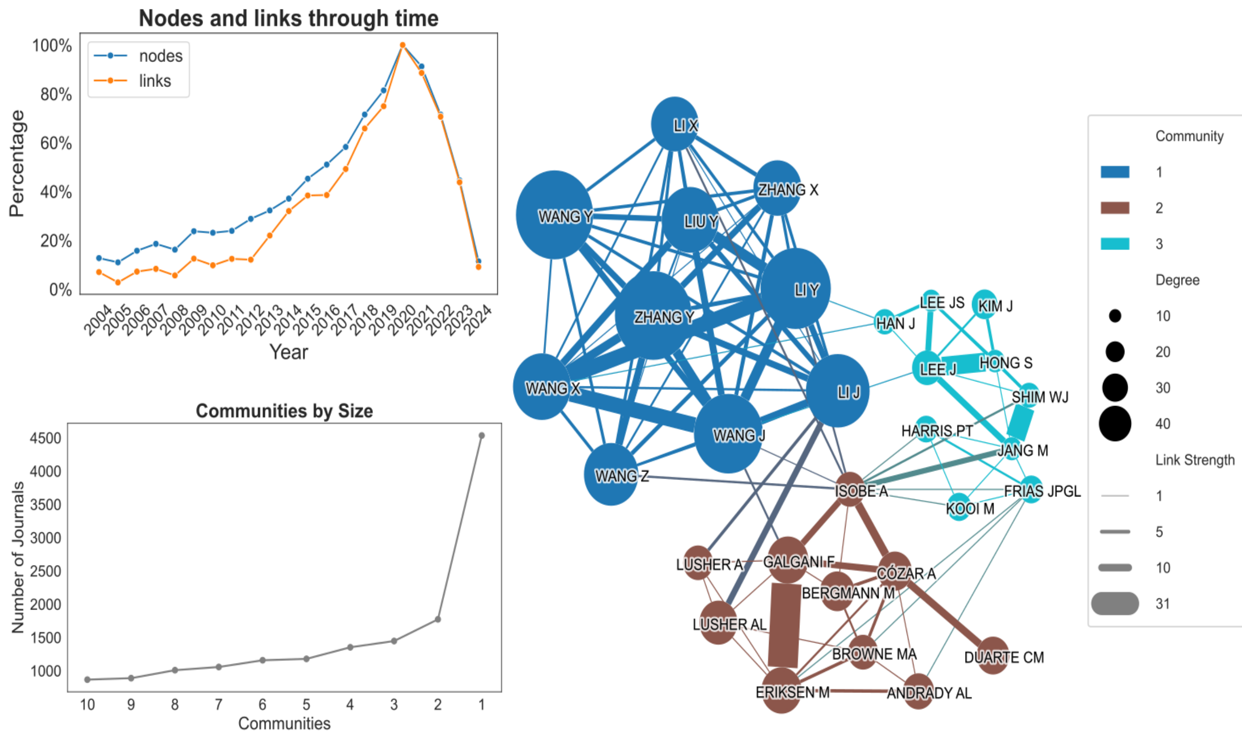

Figure 5. Author Collaboration Network.

An important point to highlight is the fact that several of the most impactful authors, such as Professors Wang Yanting and Li Yan, are affiliated with Chinese institutions. This aligns with China's leadership in terms of publication volume (152 articles). It reflects the country's recent policy measures aimed at addressing this environmental issue [43], such as the ban on the production of ultra-thin plastic bags [44].

Regarding the flow of information among the three groups illustrated in Figure 4, we can observe that each plays a specific role. In the case of Professor Wang Jung, due to his high productivity, impact (1,701 citations), and elevated h-index (15), he functions as a key knowledge-emitting node. Meanwhile, other researchers such as Professor Li Jingxi, with fewer publications but strong connectivity, may be receiving and adapting that knowledge to different contexts, thus acting as intermediary nodes.

3. Resultados

For ontology modeling we used the Protégé application[1], an open – source platform developed at Stanford University, which provides a set of tools for building domain models and knowledge-based applications with ontologies. This application has been used in different ontology modeling projects. [3] – [6] – [16] – [17] [18] – [19].

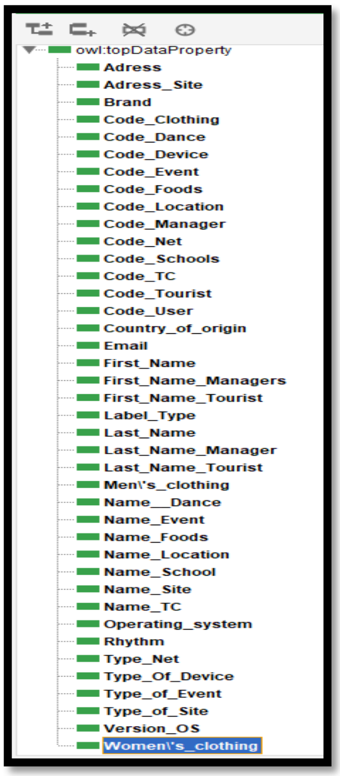

Figure 1. Data property

Conclusions

In this scientometric analysis, we have thoroughly and specifically characterized the evolution of the distribution and dynamics of scientific production related to microplastics in marine ecosystems over the period from 2014 to 2024. Through the systematic and specialized examination of 813 unique publications retrieved from the Scopus and Web of Science databases, we identified relevant patterns in research activity, collaboration networks, leading countries, the most impactful journals, and the most influential authors in the field.

In the author analysis, we observed a collaborative network composed of cohesive clusters, with researchers such as Wang Jung and Li Jingxi functioning as central nodes for knowledge

[1] https://protege.stanford.edu/

dissemination and transfer. This network structure highlights the importance of strengthening international collaborations to diversify perspectives and foster more integrative research.
This scientometric study not only provides an overview of the current state of scientific knowledge in the area but also allows us to identify thematic gaps and opportunities to guide future research. Emphasis is placed on the ecological and socio-environmental impacts posed by microplastics, underscoring the importance of promoting interdisciplinary studies with innovative approaches to help mitigate this issue within the broader context of global change. The ultimate goal is not only to generate knowledge but also to apply it to make the world a better place.

Limitations and Future Research

Conducting scientometric reviews presents significant challenges due to differences in data formats across major indexing databases such as Scopus and Web of Science. Although this study successfully addressed this limitation, it is essential to continue improving the algorithms used for data processing and enrichment, incorporating additional sources such as OpenAlex to enhance both the quality and breadth of the information.

While this scientometric analysis is grounded in objective data and builds conclusions based on quantitative results, there is a recognized need to complement these findings with qualitative research. Such approaches would allow for deeper exploration of contextual and meaningful aspects that cannot be captured through quantitative data alone, providing a more comprehensive and nuanced understanding of the topics studied.

Possible future research directions include the development of tools and algorithms for the integration and analysis of data from multiple sources, as well as the incorporation of altmetric data to assess the social impact and reception of research across various platforms and communities.

These future investigations would not only complement the findings derived from scientometric methods but also contribute to a more holistic and detailed understanding of the continuously evolving scientific and academic landscape.

References

[1]J. Wang, Z. Tan, J. Peng, Q. Qiu, and M. Li, "The behaviors of microplastics in the marine environment," Mar. Environ. Res., vol. 113, pp. 7–17, Feb. 2016, doi: 10.1016/j.marenvres.2015.10.014. Available: http://dx.doi.org/10.1016/j.marenvres.2015.10.014

[2]E. van Sebille et al., "A global inventory of small floating plastic debris," Environ. Res. Lett., vol. 10, no. 12, p. 124006, Dec. 2015, doi: 10.1088/1748-9326/10/12/124006. Available: https://doi.org/10.1088/1748-9326/10/12/124006

[3]I. Tessnow-von Wysocki and P. Le Billon, "Plastics at sea: Treaty design for a global solution to marine plastic pollution," Environ. Sci. Policy, vol. 100, pp. 94–104, Oct. 2019, doi: 10.1016/j.envsci.2019.06.005. Available: https://doi.org/10.1016/j.envsci.2019.06.005

[4]K. L. Law and R. C. Thompson, "Oceans. Microplastics in the seas," Science, vol. 345, no. 6193, pp. 144–145, Jul. 2014, doi: 10.1126/science.1254065. Available: https://doi.org/10.1126/science.1254065

[5]S. Kühn, E. L. Bravo Rebolledo, and J. A. van Franeker, "Deleterious effects of litter on marine life," in Marine Anthropogenic Litter, Cham: Springer International Publishing, 2015, pp. 75–116. doi: 10.1007/978-3-319-16510-3_4. Available: https://doi.org/10.1007/978-3-319-16510-3_4

[6]Y. Lee, J. Cho, J. Sohn, and C. Kim, "Health effects of microplastic exposures: Current issues and perspectives in South Korea," Yonsei Med. J., vol. 64, no. 5, pp. 301–308, May 2023, doi: 10.3349/ymj.2023.0048. Available: http://dx.doi.org/10.3349/ymj.2023.0048

[7]B. R. Baechler et al., "Microplastic occurrence and effects in commercially harvested North American finfish and shellfish: Current knowledge and future directions," Limnol. Oceanogr. Lett., vol. 5, no. 1, pp. 113–136, Feb. 2020, doi: 10.1002/lol2.10122. Available: http://dx.doi.org/10.1002/lol2.10122

[8]K. Ziani et al., "Microplastics: A real global threat for environment and food safety: A state of the art review," Nutrients, vol. 15, no. 3, p. 617, Jan. 2023, doi: 10.3390/nu15030617. Available: http://dx.doi.org/10.3390/nu15030617

[9]R. Pranckutė, "Web of Science (WoS) and Scopus: The titans of bibliographic information in today's academic world," Publications, vol. 9, no. 1, p. 12, Mar. 2021, doi: 10.3390/publications9010012. Available: http://dx.doi.org/10.3390/publications9010012

[10]V. K. Singh, P. Singh, M. Karmakar, J. Leta, and P. Mayr, "The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis," Scientometrics, vol. 126, no. 6, pp. 5113–5142, Jun. 2021, doi: 10.1007/s11192-021-03948-5. Available: http://dx.doi.org/10.1007/s11192-021-03948-5

[11]A. K. Shukla, M. Janmaijaya, A. Abraham, and P. K. Muhuri, "Engineering applications of artificial intelligence: A bibliometric analysis of 30 years (1988–2018)," Eng. Appl. Artif. Intell., vol. 85, pp. 517–532, Oct. 2019, doi: 10.1016/j.engappai.2019.06.010. Available: http://dx.doi.org/10.1016/j.engappai.2019.06.010

[12]A. P. da C. Araújo, T. L. Rocha, D. de M. E Silva, and G. Malafaia, "Micro(nano)plastics as an emerging risk factor to the health of amphibian: A scientometric and systematic review," Chemosphere, vol. 283, no. 131090, p. 131090, Nov. 2021, doi: 10.1016/j.chemosphere.2021.131090. Available: http://dx.doi.org/10.1016/j.chemosphere.2021.131090

[13]M. Li et al., "A global bibliometric analysis of research on microplastics from 2004 to 2020," Research Square, Research Square, Mar. 01, 2021. doi: 10.21203/rs.3.rs-216957/v1. Available: http://dx.doi.org/10.21203/rs.3.rs-216957/v1

[14]D. Borowiak and M. Krzywonos, "Bioenergy, biofuels, lipids and pigments—research trends in the use of microalgae grown in photobioreactors," Energies, vol. 15, no. 15, p. 5357, Jul. 2022, doi: 10.3390/en15155357. Available: http://dx.doi.org/10.3390/en15155357

[15]M. Santos de Moura and M. Vianna, "A new threat: assessing the main interactions between marine fish and plastic debris from a scientometric perspective," Rev. Fish Biol. Fish., vol. 30, no. 4, pp. 623–636, Dec. 2020, doi: 10.1007/s11160-020-09621-z. Available: http://dx.doi.org/10.1007/s11160-020-09621-z

[16]L. G. Valdiviezo Gonzales, C. A. Castañeda-Olivera, R. J. Cabello-Torres, F. F. García Ávila, R. V. Munive Cerrón, and E. A. Alfaro Paredes, "Scientometric study of treatment technologies of soil pollution: Present and future challenges," Appl. Soil Ecol., vol. 182, no. 104695, p. 104695, Feb. 2023, doi: 10.1016/j.apsoil.2022.104695. Available: http://dx.doi.org/10.1016/j.apsoil.2022.104695

[17]S. D. M. Oñate and A. F. T. Herazo, "Agrivoltaic systems: a contribution to sustainability," interfaces, vol. 7, no. 2, 2024, Available: https://revistas.unilibre.edu.co/index.php/interfaces/article/view/12713. [Accessed: Jan. 26, 2025]

[18]A. J. B. Berrocal and D. M. C. Rizo, "Scientometric Analysis of the Relationship Between Artificial Intelligence and Data Engineering: Trends,Collaboration, and Evolution," interfaces, vol. 7, no. 2, 2024, Available: https://revistas.unilibre.edu.co/index.php/interfaces/article/view/12714. [Accessed: Jan. 26, 2025]

[19]K. M. Romero Villareal and M. C. M. Murgas, "Antimicrobial Potential of Secondary Metabolites: AScientometric Review," interfaces, vol. 7, no. 2, 2024, Available: https://revistas.unilibre.edu.co/index.php/interfaces/article/view/12712. [Accessed: Jan. 26, 2025]

[20]M. Eriksen et al., "Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea," PLoS One, vol. 9, no. 12, p. e111913, Dec. 2014, doi: 10.1371/journal.pone.0111913. Available: http://dx.doi.org/10.1371/journal.pone.0111913

[21]I. Chubarenko, A. Bagaev, M. Zobkov, and E. Esiukova, "On some physical and dynamical properties of microplastic particles in marine environment," Mar. Pollut. Bull., vol. 108, no. 1–2, pp. 105–112, Jul. 2016, doi: 10.1016/j.marpolbul.2016.04.048. Available: http://dx.doi.org/10.1016/j.marpolbul.2016.04.048

[22]J. E. Weinstein, B. K. Crocker, and A. D. Gray, "From macroplastic to microplastic: Degradation of high-density polyethylene, polypropylene, and polystyrene in a salt marsh habitat," Environ. Toxicol. Chem., vol. 35, no. 7, pp. 1632–1640, Jul. 2016, doi: 10.1002/etc.3432. Available: http://dx.doi.org/10.1002/etc.3432

[23]C. Schmidt, T. Krauth, and S. Wagner, "Export of plastic debris by rivers into the sea," Environ. Sci. Technol., vol. 51, no. 21, pp. 12246–12253, Nov. 2017, doi: 10.1021/acs.est.7b02368. Available: http://dx.doi.org/10.1021/acs.est.7b02368

[24]A. A. Horton, A. Walton, D. J. Spurgeon, E. Lahive, and C. Svendsen, "Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities," Sci. Total Environ., vol. 586, pp. 127–141, May 2017, doi: 10.1016/j.scitotenv.2017.01.190. Available: http://dx.doi.org/10.1016/j.scitotenv.2017.01.190

[25]A. A. de Souza Machado, W. Kloas, C. Zarfl, S. Hempel, and M. C. Rillig, "Microplastics as an emerging threat to terrestrial ecosystems," Glob. Chang. Biol., vol. 24, no. 4, pp. 1405–1416, Apr. 2018, doi: 10.1111/gcb.14020. Available: https://doi.org/10.1111/gcb.14020

[26]M. Carbery, W. O'Connor, and T. Palanisami, "Trophic transfer of microplastics and mixed contaminants in the marine food web and implications for human health," Environ. Int., vol. 115, pp. 400–409, Jun. 2018, doi: 10.1016/j.envint.2018.03.007. Available: http://dx.doi.org/10.1016/j.envint.2018.03.007

[27]L. Lebreton and A. Andrady, "Future scenarios of global plastic waste generation and disposal," Palgrave Commun., vol. 5, no. 1, Jan. 2019, doi: 10.1057/s41599-018-0212-7. Available: http://dx.doi.org/10.1057/s41599-018-0212-7

[28]S. B. Borrelle et al., "Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution," Science, vol. 369, no. 6510, pp. 1515–1518, Sep. 2020, doi: 10.1126/science.aba3656. Available: http://dx.doi.org/10.1126/science.aba3656

[29]J. A. Ivar do Sul, M. F. Costa, and G. Fillmann, "Microplastics in the pelagic environment around oceanic islands of the Western Tropical Atlantic Ocean," Water Air Soil Pollut., vol. 225, no. 7, Jul. 2014, doi: 10.1007/s11270-014-2004-z. Available: http://dx.doi.org/10.1007/s11270-014-2004-z

[30]J. Hwang, D. Choi, S. Han, J. Choi, and J. Hong, "An assessment of the toxicity of polypropylene microplastics in human derived cells," Sci. Total Environ., vol. 684, pp. 657–669, Sep. 2019, doi: 10.1016/j.scitotenv.2019.05.071. Available: http://dx.doi.org/10.1016/j.scitotenv.2019.05.071

[31]M. A. Browne et al., "Accumulation of microplastic on shorelines woldwide: sources and sinks," Environ. Sci. Technol., vol. 45, no. 21, pp. 9175–9179, Nov. 2011, doi: 10.1021/es201811s. Available: https://doi.org/10.1021/es201811s

[32]C. Zhao, M. Liu, H. Du, and Y. Gong, "The evolutionary trend and impact of global plastic waste trade network," Sustainability, vol. 13, no. 7, p. 3662, Mar. 2021, doi: 10.3390/su13073662. Available: http://dx.doi.org/10.3390/su13073662

[33]S. Huang et al., "Plastic waste management strategies and their environmental aspects: A scientometric analysis and comprehensive review," Int. J. Environ. Res. Public Health, vol. 19, no. 8, p. 4556, Apr. 2022, doi: 10.3390/ijerph19084556. Available: http://dx.doi.org/10.3390/ijerph19084556

[34]A. K. Panda, R. K. Singh, and D. K. Mishra, "Thermolysis of waste plastics to liquid fuelA suitable method for plastic waste management and manufacture of value added products—A world prospective," Renew. Sustain. Energy Rev., vol. 14, no. 1, pp. 233–248, Jan. 2010, doi: 10.1016/j.rser.2009.07.005. Available: http://dx.doi.org/10.1016/j.rser.2009.07.005

[35]A. L. Andrady, "Microplastics in the marine environment," Mar. Pollut. Bull., vol. 62, no. 8, pp. 1596–1605, Aug. 2011, doi: 10.1016/j.marpolbul.2011.05.030. Available: http://dx.doi.org/10.1016/j.marpolbul.2011.05.030

[36]J. C. Anderson, B. J. Park, and V. P. Palace, "Microplastics in aquatic environments: Implications for Canadian ecosystems," Environ. Pollut., vol. 218, pp. 269–280, Nov. 2016, doi: 10.1016/j.envpol.2016.06.074. Available: http://dx.doi.org/10.1016/j.envpol.2016.06.074

[37]Z. Wang et al., "Preferential accumulation of small (<300 μm) microplastics in the sediments of a coastal plain river network in eastern China," Water Res., vol. 144, pp. 393–401, Nov. 2018, doi: 10.1016/j.watres.2018.07.050. Available: http://dx.doi.org/10.1016/j.watres.2018.07.050

[38]T. Mani, A. Hauk, U. Walter, and P. Burkhardt-Holm, "Microplastics profile along the Rhine river," Sci. Rep., vol. 5, no. 1, p. 17988, Dec. 2015, doi: 10.1038/srep17988. Available: http://dx.doi.org/10.1038/srep17988

[39]J. Wang et al., "Microplastics in the surface sediments from the Beijiang River littoral zone: Composition, abundance, surface textures and interaction with heavy metals," Chemosphere, vol. 171, pp. 248–258, Mar. 2017, doi: 10.1016/j.chemosphere.2016.12.074. Available: http://dx.doi.org/10.1016/j.chemosphere.2016.12.074

[40]J. Li, F. Gao, D. Zhang, W. Cao, and C. Zhao, "Zonal distribution characteristics of microplastics in the southern Indian Ocean and the influence of ocean current," J. Mar. Sci. Eng., vol. 10, no. 2, p. 290, Feb. 2022, doi: 10.3390/jmse10020290. Available: http://dx.doi.org/10.3390/jmse10020290

[41]X. Wu, X. Zhang, H. Liao, J. Guo, Z. Ma, and Z. Fu, "Microplastics and tetracycline affecting apoptosis, enzyme activities and metabolism processes in the Aurelia aurita polyps: insights into combined pollutant effects," Front. Mar. Sci., vol. 12, Mar. 2025, doi: 10.3389/fmars.2025.1545131. Available: http://dx.doi.org/10.3389/fmars.2025.1545131

[42]X. Xu et al., "Marine microplastic-associated bacterial community succession in response to geography, exposure time, and plastic type in China's coastal seawaters," Mar. Pollut. Bull., vol. 145, pp. 278–286, Aug. 2019, doi: 10.1016/j.marpolbul.2019.05.036. Available: http://dx.doi.org/10.1016/j.marpolbul.2019.05.036

[43]P. G. C. Nayanathara Thathsarani Pilapitiya and A. S. Ratnayake, "The world of plastic waste: A review," Cleaner Materials, vol. 11, no. 100220, p. 100220, Mar. 2024, doi: 10.1016/j.clema.2024.100220. Available: http://dx.doi.org/10.1016/j.clema.2024.100220

[44]C. Wang, L. Zhao, M. K. Lim, W.-Q. Chen, and J. W. Sutherland, "Structure of the global plastic waste trade network and the impact of China's import Ban," Resour. Conserv. Recycl., vol. 153, no. 104591, p. 104591, Feb. 2020, doi: 10.1016/j.resconrec.2019.104591. Available: http://dx.doi.org/10.1016/j.resconrec.2019.104591